

Part 1. Report Cover

Report Number: 00KPT35R

Title: Performance Oriented Packaging Testing of an  
MS27684-8 Removable Head Drum, 12-Gallon, with  
1-Quart, Rectangular Metal Cans (Quantity of 12) Packing  
Groups I, II, III

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Requesting Organization:

Defense Logistics Agency  
Defense Distribution Center  
ATTN: DDC-TO  
2001 Mission Drive  
New Cumberland, PA 17070-5000

Requesting Organization's Reference(s):

DLA memo of 14 Oct 99, Subj: Performance Oriented Tests to be Performed in 2000

Part 2. Test Results: \_\_ single X combination \_\_ composite

### Section I. Pre-test Conditions

For initial testing, four drums (herein referred to as specimens 1 through 4) were received in new condition.

The following identification scheme designates the packaging specimen used for the test indicated. Assignments were made at random, in no particular order or sequence.

<u>Specimen No.</u>	<u>Test</u>
1	repetitive shock vibration test diagonal bottom chime, drop test diagonal top chime, drop test flat onto seam, drop test flat onto top, drop test flat onto bottom, drop test
2	stacking test hydrostatic pressure test
3	stacking test hydrostatic pressure test
4	stacking test hydrostatic pressure test

Prior to repetitive shock and drop testing, the drum was packed as noted in Appendix C.

### Section II. Summary

	<u><b>PG I</b></u> <b>SG 1.2</b>	<u><b>PG II</b></u> SG 1.2	<u><b>PG III</b></u> SG 1.2
A. Drop Test - 71 in. (1.8 m)	<b>PASS</b>	PASS	PASS
B. Stacking Test -	<b>PASS</b>	PASS	PASS
C. Vibration Test -	<b>PASS</b>	PASS	PASS
D. Leakproofness Test -	<b>N/A</b>	---	---

E.	Hydrostatic Pressure Test -	<b>PASS</b>	PASS	PASS
F.	Water Resistance Test -	<b>N/A</b>	---	---
G.	Compatibility Test -	<b>N/A</b>	---	---

To be certifiable, the configuration must pass the applicable tests for the type of packaging, intended lading, and mode(s) of shipment. This report is applicable to transportation by air.

### Section III. Discussion

Description of test results, including any rationale for variations.

- A. Drop test:        cold conditions ( 0 deg F, 72 hr)  
                         X   ambient conditions  
                           standard conditions (23 deg C & 50% RH)

<u>Drop Orientations</u>	<u>Pass /Fail</u>	See 49 CFR 178.603
Diagonal bottom chime:	X /	
Diagonal top chime:	X /	
Flat sidewall (seam):	X /	
Flat top:	X /	
Flat bottom:	X /	

- B. Stacking test: See 49 CFR 178.606

  X   24 hours        days        dynamic compression (periodic retest)

at     23 deg C & 50% RH   X   ambient     104 deg F conditions.

Leakage/rupture was not noted. Leaked/ruptured after   N/A  .

Maximum deflection was   N/A   in. No deterioration in evidence.

The three specimens, loaded as noted in Appendix C, did not leak, did not rupture, and showed no evidence of damage or deterioration. The total top load (1000 lb.) was greater than the minimum required based on the density of the heaviest liquid anticipated. Stacking stability was maintained. The stacking test was also performed using empty drums with a top load of 1000 lb. Again, stacking stability was maintained.

- C. Vibration test: As a means to determine capability, a drum was loaded as noted in Appendix C, and was tested for 60 minutes on a 3000-lb vibration table (rotary motion) that has a 1-inch vertical

double amplitude (peak to peak displacement) such that the drum was raised from the platform (liftoff) to such a degree that a piece of steel strapping (1.6 mm) could be passed between the bottom of the package and the platform. No apparent damage or distortion, as a result of this test at (226 rpm), was visible upon inspection. The drum remained closed and the contents (water) were completely retained. See 49 CFR 178.608.

D. Leakproofness test: The leakproofness test (49 CFR 178.604) was not conducted on the drum, because the outer packaging is not intended for containment of liquids.

E. Internal Pressure/Hydrostatic Pressure test: See 49 CFR 178.605

     N/A (surface only; solids); 49 CFR 178.605(a)

  \* 250 kPa (36 psi) for   X   5      30 min.; 49 CFR 178.605(d)  
49 CFR 173.27(c) (3) (ii)

  X   100 kPa (15 psi) for   X   5      30 min.; 49 CFR 178.605(d) (2)  
49 CFR 173.27(c) (3) (ii)

  X   95 kPa (14 psi) for      5      30 min.; 49 CFR 173.27(c) (2) (i)

  X   80 kPa (12 psi) for      5      30 min.; 49 CFR 173.27(c) (3) (ii)

  X   75 kPa (11 psi) for   X   5      30 min.; 49 CFR 173.27(c) (2) (i)

\* None of the three test samples maintained 36 psi for the required full five minutes. The rubber gasket was brushed (both sides) with talcum powder (NSN 8510-817-0295) and the locking ring was tapped repeatedly during tightening with a rubber mallet until the ring completely closed around the cover, leaving no gap between the ends of the ring. The three drums maintained pressure of 27, 30, and 31 psi respectively. It should be noted that the ends of the container bulged significantly at these pressures. It should also be noted that the manufacturer only certifies the drums to 15 psi.

The test pressure for determining the ability of the packaging to maintain a designated hydrostatic pressure is not always specific to a packing group. A test pressure based on the vapor pressure of the intended liquid contents at 50 or 55 degrees C applies.

F. Water resistance (Cobb Method) test (fiberboard):

This test is only for fiberboard, as required by the standards for fiberboard boxes (49 CFR 173.516).

G. Compatibility test (plastics packaging only):

Compatibility testing (a procedure specified in appendix B to part 173, as required by 49 CFR 173.24(e) (3) (ii) is only required for plastics packaging intended to contain liquid hazardous materials. Compatibility testing is usually performed during the manufacturing process before filling.

### Part 3. Test Personnel

The personnel who performed the aforementioned testing, or had a role in the testing, evaluation, and/or documentation, as reported herein are recorded in the test files.

#### Part 4. References

- A. Title 49 Code of Federal Regulations, Parts 173 and 178, 1 October 1999 edition.
- B. ASTM D 4919, Specification for Testing of Hazardous Materials Packagings.
- C. ASTM D 999, Standard Method for Vibration Testing of Shipping Containers.
- D. TAPPI Standard: T 441 Water Absorptiveness of Sized (Non-Bibulous) Paper and Paperboard (Cobb Test).

#### Part 5. Equipment

Item	Manufacture	Serial No.	Cal. Exp. Date
6-inch dial calipers	Brown & Sharp	599-579-2	9-24-00
3,000-lb vibration table	L.A.B.	318023	N/R
5,000-lb electronic scale	TCI	27331	10-19-00
600-lb electronic scale	Excell	MKZ09600	6-30-00
release hook	Peck & Hale	Release-A-Matic	N/R
drop tester	L.A.B	4410646	N/R
100 psi pressure gauge	Duragauge	1912	10-05-00
Temperature Chamber	Russell	RD-16-3-3	6-7-00

## Appendix A

### Test Applicability

- (1) Based on the drop height, computed stacking weight, and internal pressure maintenance, this test report is applicable for all modes of transportation including air and surface means (road, rail, and water) when the liquid hazardous substance intended for containment by the tested packaging is per the equivalencies listed in Appendix B, Section III of this report. Transportation by commercial (cargo and passenger) or military air is as permitted by regulation for the hazardous item. A test pressure based on the vapor pressure of the intended liquid contents applies.
- (2) Pass/fail conclusions were based on the particular drum specimens, test loads, and the limited quantities submitted for test. Extrapolation to other materials, other manufacturers, and other applications, different inner packaging, container sizes, or lesser inner quantities is the responsibility of the packaging design agency or applicable higher authority.
- (3) Reference to specification materials has been made based either on the information provided by the requester, the manufacturer, or the markings printed on, attached to, or embossed on the packaging. It was not possible to identify the exact composition of the drum construction materials.
- (4) Testing was performed per Title 49 Code of Federal Regulations.
- (5) Performance testing was undertaken and completed at the request of an agency responsible for the shipment of dangerous goods. The successful completion of required performance tests does not, by itself, authorize the marking and transportation of the dangerous goods. Applicable modal regulations should be consulted concerning the relationship of performance testing completed and the dangerous goods.
- (6) The required performance tests are intended to evaluate the performance of the packaging components. The criteria used to evaluate packaging performance is whether the contents of the packaging are retained within the outer packaging, should damage to the outer packaging occur, and secondly, if any inner packaging of hazardous materials leaks, ruptures, or is damaged so as to affect transportation safety. The successful completion of the required tests does not ensure the undamaged delivery or survivability of the actual commodity/item. Separate testing is necessary to ensure the stability of any explosive item.

Part 3. Introduction: Brief description of why specific tests were performed and rationale for the test product selected (if applicable).

Packing Group I (greater danger) testing was requested for a 12-gallon, MS27684-8, removable head steel drum having as the intended contents twelve, 1-quart, rectangular metal cans. The configuration to be tested is intended to be applicable to a large assortment of liquid products contained in rectangular metal cans, in small volumes of 1 quart or less. For lesser volumes, variations to testing configuration can be determined by referring to 49 CFR 178.601 (g).

Water was used as a test liquid as permitted by Title 49 Code of Federal Regulations (CFR). Substitution for the actual hazardous item (material) is permitted by 49 CFR 178.602.

A secondary closure utilizing filament reinforced tape was used in accordance with accepted packaging practice.

Three combination packages made to the above described configuration were subjected to static loading. This is a U.S. DOT approved method of stack testing, especially when the combination packaging has wide application. The stacking test was also performed using empty drums with a top load of 1000 lb. Again, stacking stability was maintained. One package (configuration) was subjected to vibration and drop (rough handling) testing as prescribed in ASTM D 4919. These tests are designed to simulate the shock and vibration a package (configuration) may encounter when being shipped worldwide by truck, rail, or ocean going transport. The order of testing was vibration, then drop testing.

In conducting the drop test, the packed drum was dropped first diagonally onto the top chime, followed by a drop diagonally onto the bottom chime. A drop flat onto the seam, top, and bottom followed. Between all drop orientations, the drum was dropped onto five different surfaces or edges. The decision to use the same container (configuration) for all drops was based on the relatively minimal damage demonstrated during previous testing. Five drops per drum exceeds 49 CFR 178.603 requirements, as well as both UN and ASTM recommendations (i.e., one drop diagonally onto a chime, one drop on the next weakest part, repeated using six samples total). The use of one configuration for multiple tests and drops is DOD policy as stated in draft regulation DLAR 4145.41/AR 700-143/AFR 71-5/NAVSUPINST 4030.55/MCO 4030.40, Packaging of Hazardous Material, the use of which was directed by MMDOS Letter 94-1 (same title), and its use extended by agreement during the DOD Performance Oriented Packaging Working Group meeting, Richmond, VA, 19-21 Sep 95.

Due to the variety of the items to be packaged, testing was actually conducted according to the parameters for dense liquids (those with specific gravity up to 1.8) belonging to Packing Group II. This would equate to rough handling tests equivalent to those for Packing Group I for liquids having a specific gravity of 1.2 or less, and for Packing Group III liquids having specific gravity of 2.7 or less.

For each orientation for the drop test (49CFR 178.603), a free fall drop table, set for 71 inches (1.8 meters), was used. The impact surface was the 2-inch steel impact plate of the table.

The total top load (1000 lb.) used for the stack test (49 CFR 178.606), was greater than the minimum

required based on the density of the heaviest liquid anticipated.

The leakproofness test (49 CFR 178.604) was not conducted on the drum, because the outer packaging is not intended for the containment of liquids.

The leakproofness test of the metal can is not required, because the can is an inner packaging in a combination packaging.

The hydraulic test (49 CFR 178.605) was not performed on the metal can, because a specific manufacturer and metal and/or can specification may not always be identified. For combination packaging to be transported by air, if the inner packaging is not able to maintain the designated internal pressure (49 CFR 173.27(c)), an overpack must be used. The overpack must be capable of maintaining the designated internal pressure. Therefore, the hydraulic test was performed on the metal drum in order to determine the potential for air transportation eligibility of the metal drum. Since the liquid contents were not identified and the associated vapor pressure at 50 or 55 degrees C was not available, the minimum test pressure, 15 psi, for the drum specification was selected. The hydrostatic (hydraulic) test was performed using the applicable section of ASTM D 4919. Each of the three test drum covers was drilled and fitted with an air valve and sealed using the normal rubber gasket, lid and locking ring. The drum was tested in the as received condition. The drums were to be pressurized in steps of increasing pressure until failure. Initially, the drums were each pressurized to 11 psi, the minimum pressure for paint, and paint related product. After maintaining the pressure for 5 minutes, the pressure was increased sequentially to 12, 14, and 15 psi, the minimum pressure for the drum specification. After maintaining that pressure at each successive level for 5 minutes, the pressure was raised to 36 psi, the minimum test pressure for Packing Group I single packagings.

The Cobb Method Test for water absorptiveness was not performed, because the test is not a performance test. The Cobb Method Test, addressed in 49 CFR 178.516, Standards for Fiberboard Boxes, is a material specification test only for the fiberboard to be used for outer packagings.

The vibration test (49 CFR 178.608) was performed to be in compliance with U.S. Department of Transportation standards for packagings bearing the United States mark (USA) as a component of the packaging certification marking. The test was conducted as prescribed by ASTM D 999, method A1 (Repetitive Shock Test). The test run lasted for 1 hour.

Compatibility testing (a procedure specified in appendix B to part 173, as required by 49 CFR 173.24(e)(3) (ii)) is only required for plastics outer packagings intended to contain liquid hazardous materials. This procedure, therefore, is not required since the drum is made of steel. Compatibility testing is usually performed during the manufacturing process before filling.



## Appendix B

### Test Data Sheet

#### Section I. Test Product

Physical State:        \_\_\_ solid   X   liquid    \_\_\_ gas

Test Product Density/Specific Gravity: 1.0

Amount Per Container (Configuration):

1 quart        (3 gallon), rated  
2.075 lb.      (24.9 lb.)  
2.39 lb.      (28.6 lb.) packed

Gross Weight: 59.1 lb.

Test Weight: 26.7 kg

Density/Specific Gravity: 1.0

Consistency/Viscosity: N/A

Flash Point: N/A

#### Section II. Test Parameters

Drop Height: Ref: 49 CFR part178.603

  X   71 in.; 1.8 m (PG I, II, & III, SG 1.2 or solids)  
\_\_\_ 47 in.; 1.2 m (PG II, & III, SG 1.2 or solids)  
\_\_\_ 32 in.; 0.8 m (PG III, SG 1.2 or solids)  
from \_\_\_ (PG I: SG x 1.5 m, SG x 59.06 in.,  
      \_\_\_ (PG II: SG x 1.0 m, SG x 39.37 in., 1.2 x 39.37 in.  
      \_\_\_ (PG III: SG x 0.67 m, SG x 26.38 in., 1.8 x 26.38 in.

Unless otherwise computed for more dense liquids, water (SG = 1) represents a solution having a specific gravity of 1.2 or less. Equivalent specific gravity derived from drop height is as follows:

PG factor x density (or SG) = drop height, thus SG = drop height/PG factor (49 CFR 178.603) 0.67 m x SG = 1.2 m, thus SG = 1.8, PG III.

Stacking Weight/Dynamic Compression Force: Ref: 49 CFR 178.606

Liquids:  $A = (n-1) [w + (s) (v) (8.3) (.98)] c$ ;

where: A = applied load in pounds

n = minimum number of containers that when stacked reach a height of  
10 feet (round up to the next integer)

s = specific gravity of lading

w = maximum weight of one empty container in pounds

v = actual capacity of container (rated capacity + outage) in gallons

8.3 corresponds to the weight (lb.) of 1 gallon of water

0.98 corresponds to maximum fill (98% max. capacity)

316 lb. Minimum required (PG I, SG 1.2); 1000 lb. actual  
 $A = (n-1) [w + (s) (v) (8.3) (.98)]$

where: n = (120 in./21 in.)

= 5.7 rounded up to 6

w = 34 lb.

s = 1.2

v = (3 gal)

$A = (6-1) [34 + (1.2) (3) (8.3) (.98)] = 316.41 \text{ lb.}$

390 lb. Minimum required (PG II, SG 1.8); 1000 lb. actual  
 $A = (n-1) [w + (s) (v) (8.3) (.98)]$

where: n = (120 in./21 in.)

= 5.7 rounded up to 6

w = 34 lb.

s = 1.8

v = (3 gal)

$A = (6-1) [34 + (1.8) (1) (8.3) (.98)] = 389.62 \text{ lb.}$

499 lb. Minimum required (PG III, SG 2.7); 1000 lb. actual  
 $A = (n-1) [w + (s) (v) (8.3) (.98)]$

where: n = (120 in./21 in.)

= 5.7 rounded up to 6

w = 34 lb.

s = 2.7

v = (3 gal)

$A = (6-1) [34 + (2.7) (1) (8.3) (.98)] = 499.43 \text{ lb.}$

Solids  $A = (n-1) (w) (.95)$

where: A = applied load in pounds

n = minimum number of containers that when stacked, reach a height of  
10 feet (rounded up to the next integer)

w = maximum weight of one packed container in pounds  
.95 corresponds to maximum fill (95% maximum capacity)

$\frac{N/A}{A} = \frac{(n-1)(w)(.95)}{w} = \frac{(n-1)(.95)}{1} = \text{lb. actual}$

Internal/Hydrostatic Test Pressure (liquids only) Ref: 49 CFR 178.605 and 173.27

	N/A (surface only; solids)
*	psi/250 kPa (36 psi) (PG I single minimum)
X	14.5 psi/100 kPa (15 psi) (PG II/III single minimum)
X	13.8 psi/95 kPa (14 psi) (combination minimum, PG N/A)
X	11 psi/75 kPa (other)
X	15 psi/103.4 kPa (other, drum specification)
	psi/ kPa (other)

Altitude:   X   N/A Vacuum:   X   N/A  
         ft,          deg F,          hr          in. Hg,          min.

## Section III. Equivalencies for Liquids

	Specific Gravity	Amount Total (each)		Gross Weight (pounds)	Test Weight (kilograms)
	see note 1	Container		see note 2	see note 2
water	1.0	24.9	(2.1) lb.	59.1	26.8
PG I		29.3	(2.4) lb.	74.9	34.0
PG II		44.8	(3.7) lb.	90.1	41.0
PG III		67.2	(5.6) lb.	112.5	51.1

Note 1: Equivalent specific gravity derived from drop height as follows:

PG factor x density (or SG) = drop height, thus SG = drop height/PG factor (49CFR 178.603)

PG I: 1.5 m x SG = 1.8 m, thus SG = 1.2 PG

PG II: 1.0 m x SG = 1.8 m, thus SG = 1.8

PG III:  $0.67m \times SG = 1.8 m$ , thus  $SG = 2.7$

Unless otherwise computed for more dense liquids, water ( $SG = 1$ ) represents a solution having a specific gravity of 1.2 or less.

Note 2: Gross and test weights include packaging (59.1 lb., 26.7 kg) and liquid contents.

## Appendix C

### Packaging Data

#### Exterior Shipping Container

UN Type: Steel removable head drum UN Code 1A2

Specification Type: Drum, Metal-Shipping and Storage

Specification Number (s): MIL-D-6054; MS27684-8 (drum assembly);  
MS27684-18 (container body); MS27684-23 (shipping cover)  
MS27684-25 (gasket); MS27684-31 (locking ring)

Nominal (rated) Capacity: 12 gal

Container Manufacturer: MIRAX (bottom marking); CAGE 85717  
Mirax Chemical Products, Corporation  
St. Louis, Missouri 63139

Nomenclature: Drum, Steel, Shipping and Storage

Date (s) of Container Manufacture: 96 (embossed on bottom)

Material: Steel, 20 gauge (embossed on bottom)

NSN: 8110-00-254-5716 (drum assembly)

Contract No. N/A Purchase Order No. N/A

Tare Weight (empty drum): 15.1 lb. (actual, w/lid & ring)

Dimensions: 21 in. height, 14.5 in. diameter (OD)  
20 in. usable inside height (IAW MIL-D-6054)  
13.75 in. inside diameter (IAW spec)

Closure (Method/Type): Locking ring; nut and bolt, tightened to 6+/- .5 foot pounds;  
pre-shaped, rubber gasket

Closure Dimensions: .75 in. in height (OD) (locking ring)  
1.5 in. around (OD) (locking ring)  
.375 in. by 3.25 in. (bolt)

Closure Specification Number (s):

MS27684-31 (locking ring)

MS27684-25 (gasket) NSN 5330-01-451-1457

MS27684-23 (drum cover, style 1) NSN 8110-00-222-3135

Closure Manufacturer (s): Nut and Bolt, not marked

Banding Type: N/A

Banding Specification No (s): N/A

Banding Dimensions: N/A

Banding Manufacturer: N/A

Banding Position (s): N/A

0 girthwise bands, encircling top, bottom, and sides

0 lengthwise bands, encircling top, bottom, and ends

0 horizontal bands, encircling sides and ends

Cushioning/Dunnage: Vermiculite - Grade 3 of ASTM C 516 (see additional description) Note.  
No bottom pad, top pad

Cushioning/Dunnage Specification Type (s): Not identified

Note. Recommended use - Commercial Item Description, Vermiculite, Absorbent  
(For Packaging Liquid Hazardous Material)

Cushioning/Dunnage Specification Number (s): N/A

Note. Recommended use - A-A-52450, NSN: 8135-01-324-2664

Cushioning/Dunnage Manufacturer (s): Not identified

Cushioning/Dunnage Dimensions: N/A

Leakproof Liner: A 4-mil polyethylene bag minimum size 21 inches wide by 41 inches deep shall be used.

Additional Description:

- a. A fine grade of vermiculite (2 inch thick layer) was placed in the bottom of the drum. Six cans were placed upright on the vermiculite and more vermiculite was then packed around and over the top of the cans one inch thick. A fiberboard separator was placed on top of the vermiculite and covered with one inch of vermiculite. Another six cans were placed on the vermiculite and more vermiculite was placed around and over the top of the cans covering them with two inches of vermiculite. One inch of vermiculite separated the cans from each other and the sides of the drum.

One

- b. Before closing, the drum was shaken down to settle the absorbent material. Additional absorbent material was added, as necessary to make a firm pack.
- c. The quantities of absorbent material DO NOT meet the guidelines for absorbent material outlined in AFJMAN 24-204/ TM 38-250/NAVSUP PUB 505/MCO P4030.19F/DLAM 4145.3, Preparing Hazardous Materials for Military Air Shipments.
- d. Care must be exercised when selecting vermiculite to avoid introducing water or surfactants (treatments to reduce dust) into the package. Only untreated vermiculite should be used. The use of CID A-A-52450, Vermiculite, Absorbent (For Packaging Liquid Hazardous Materials) is recommended.

#### Inner Packaging of Combination Packaging

Quantity of Inner Containers: 12

Capacity: 1 quart each

Specification Type: N/A

Specification Number (s): N/A

Type/Nomenclature: Metal can, rectangular with metal cap

NSN: Not Available

Manufacturer/Distributor: Freund Can Company

Manufacturer/Distributor Part No.: Catalogue No. 1914

Date of Manufacture: Not marked

Material: Metal

Tare Weight (empty can): 0.31 lb. (approx.); 141 g

Dimensions: 7.5 inches in height  
4.6 inches in length  
2.4 inches in width

Closure (Method/Type): Screw Cap

Closure Specification Number (s): Not marked

Closure Manufacturer: Not marked

Closure Dimensions: 0.5 inches in height (OD)  
1-3/4 inches in diameter (OD)  
3/8 inch in height (ID)  
1-5/8 inch in diameter (ID)

Secondary Closure: Filament-reinforced tape

Secondary Closure Specification Type (s);

- (1) Equivalent to - ASTM Standard Specification for Pressure Sensitive Tape for Packaging, Filament-Reinforced NSN: 7510-00-582-4772  
ASTM D 5330-93, type II (medium tensile)

Secondary Closure Dimensions: 1 inch wide

Secondary Closure Manufacturer (s): not labeled

Cushioning/Dunnage Type: N/A

Cushioning/Dunnage Specification: N/A

Cushioning/Dunnage Specification Number (s): N/A

Cushioning/Dunnage Dimensions: N/A

Cushioning/Dunnage Manufacturer: N/A

Leakproof Liner: N/A

Static Electricity Protection: N/A